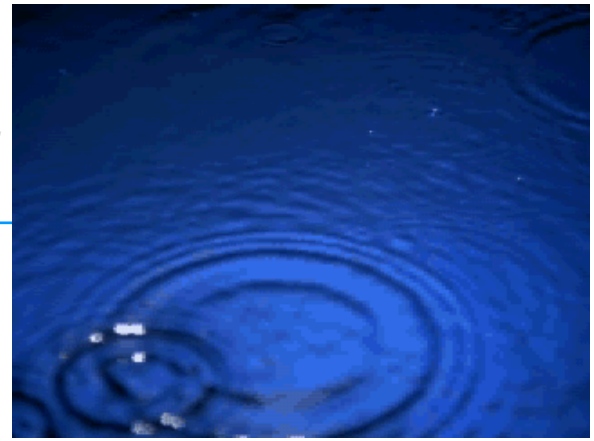
# GPM
## Global Precipitation Measurement



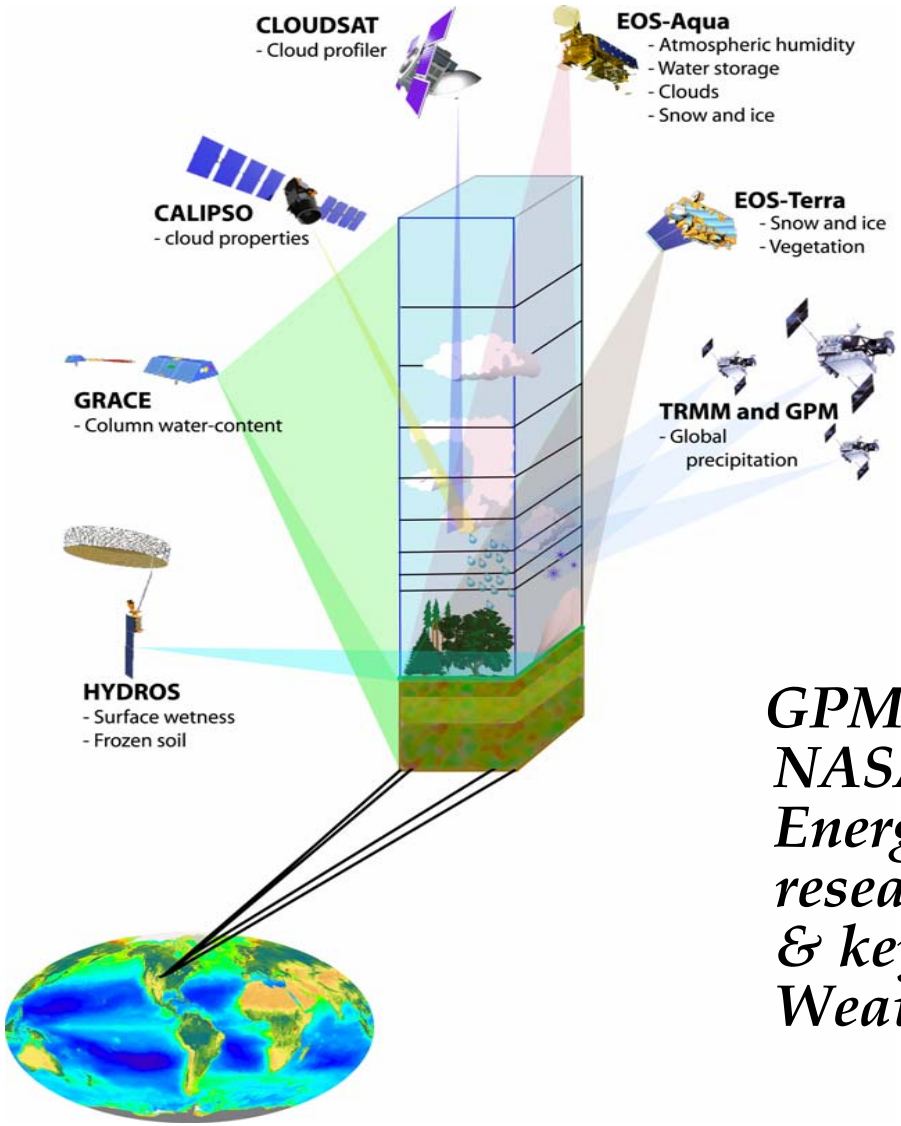
## GPM and HF PMW Observations

*Arthur Y. Hou, GPM Project Scientist*
*Gail Skofronick-Jackson, PMM Science Staff*

*October 11, 2005*

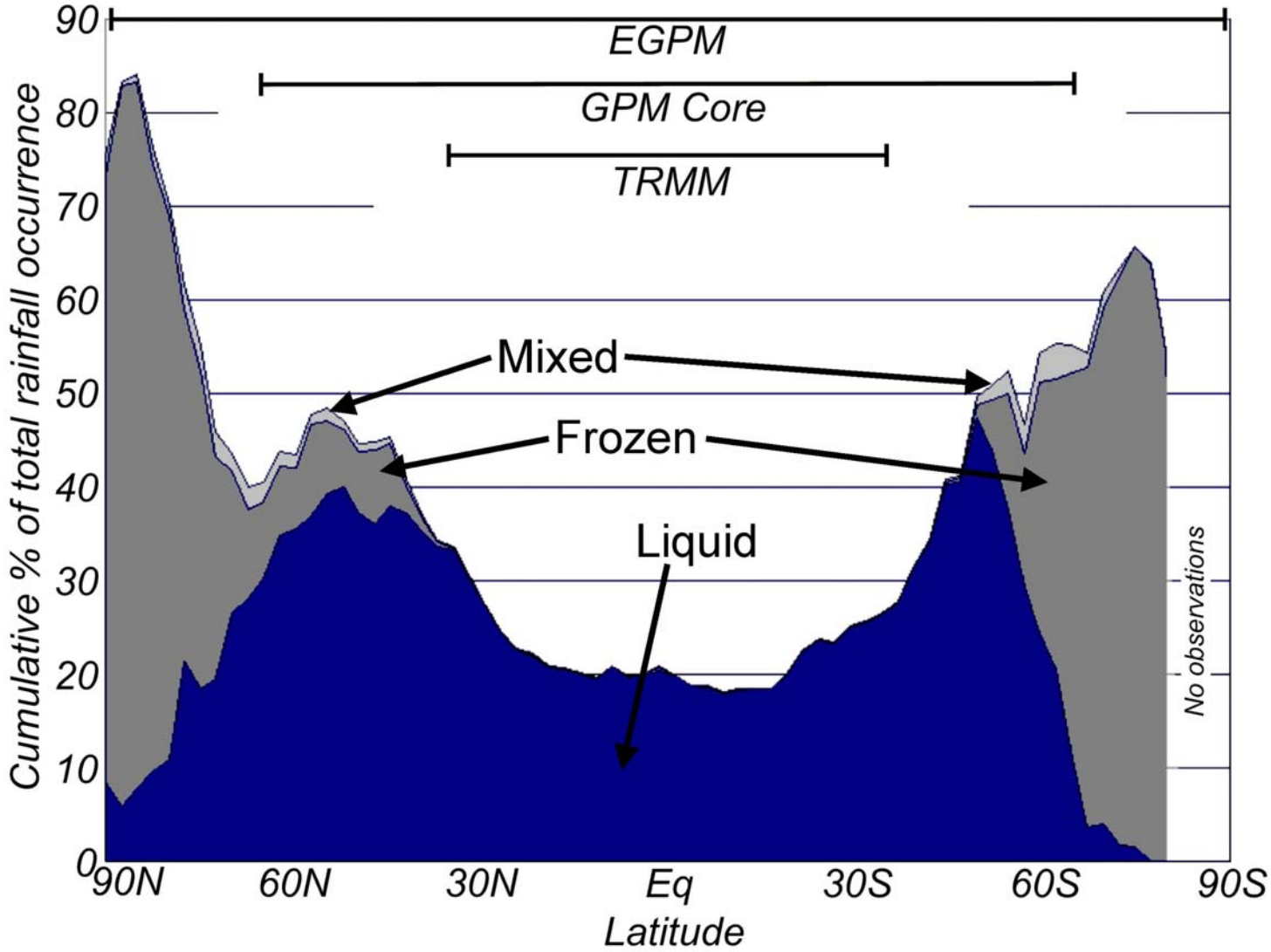
# ** NEWS FLASH **

- *NASA HQ formally approved the incorporation of high frequency (HF) capability on both GMI instruments in September, 2005.*
- *Channel specifications: 165.5 GHz and 183.31 GHz.*
- *The ability to measure light rain and detect snowfall at mid and high latitudes in cold seasons makes GPM truly a global measurement mission.*
- *GPM is looking to this community to build upon HF research to make effective use of DPR and GMI to improve GPM precipitation products over both land and oceans.*



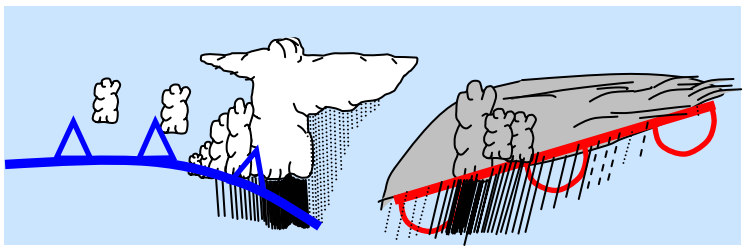

***GPM is flagship mission for NASA's Global Water and Energy Cycle (GWEC) research and applications & key measuring element in Weather Science Focus Area***

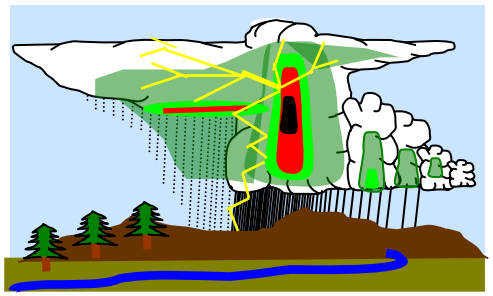
# Precipitation regimes



# GPM science objectives

- ***Precipitation measurement technology***: *advancing precipitation measurement capability from space*
  - *through combined use of active and wide-band passive remote-sensing techniques*
- ***Water/energy cycle variability***: *advancing understanding of global water/energy cycle and fresh water availability*
  - *through better measurement of the space-time variability of global precipitation*
- ***Weather prediction***: *improving NWP skills*
  - *through more accurate and frequent measurement of instantaneous rain rates*
- ***Hydrometeorological prediction***: *advancing flood-hazard and fresh-water-resource prediction capabilities*
  - *through improved temporal sampling and spatial coverage*
- ***Climate prediction***: *improving climate prediction capability*
  - *through better understanding of precipitation microphysics, surface water fluxes, soil moisture storage, and latent heating*





- ***Applications*** *- Making GPM data products and resources accessible to users and stakeholders beyond the traditional precipitation science community - by establishing broader and more effective use of space-based precipitation data products in decision-support of a wide variety of societal applications*
  - *Freshwater Utilization and Resource Management*
  - *Natural Hazard Monitoring/Prediction (Flood Warnings, Hurricane and Cyclone Observation, Winter Weather Events)*
  - *Operational Weather Forecasting*
  - *Climate Change Assessment*
  - *Agriculture*
  - *Transportation*
  - *Policy and Planning*

- ***Outreach*** *- Making immediate precipitation data products available to:*
  - *Students, teachers, and researchers in educational institutions via direct network access to GPM data products*
  - *Commercial and public television enterprises via near-real time graphic rain imagery*
  - *Any government, industrial, and academic data user agencies as well as private homes*

***Accomplishing GPM science objectives will directly feed into applications.***

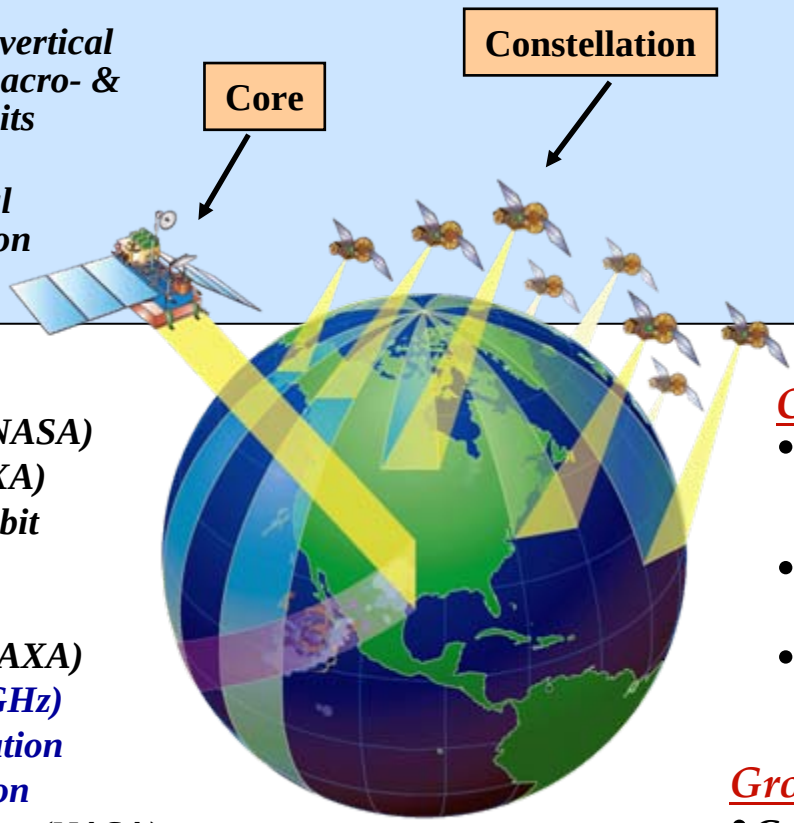
# GPM Reference Concept

## OBJECTIVES

- *Understand horizontal & vertical structure of rainfall, its macro- & micro-physical nature, & its associated latent heating*
- *Train & calibrate retrieval algorithms for constellation radiometers*

## OBJECTIVES

- *Provide sufficient global sampling to significantly reduce uncertainties in short-term rainfall accumulations*
- *Extend scientific and societal applications*




## Core Satellite

- *TRMM-like spacecraft (NASA)*
- *H2-A rocket launch (JAXA)*
- *Non-sun-synchronous orbit*
  - *~ 65° inclination*
  - *~407 km altitude*
- *Dual frequency radar (JAXA)*
  - *Ku-Ka Bands (13.6-35 GHz)*
  - *~ 4 km horizontal resolution*
  - *~250 m vertical resolution*
- *Multifrequency radiometer (NASA) (Conically-Scanning)*
  - *10.65, 18.7, 23.8, 36.5, 89.0 GHz*
  - *166, 183.3±~3, 183.3±7 or 9 GHz*

**High Frequencies Approved Sept. 2005**

## Constellation Satellites

- *Pre-existing operational-experimental & dedicated satellites with PMW radiometers*
- *Revisit time*
  - *3-hour goal at ~90% of time*
- *Sun-synch & non-sun- synch orbits*
  - *600-900 km altitudes*

## Ground Validation Sites

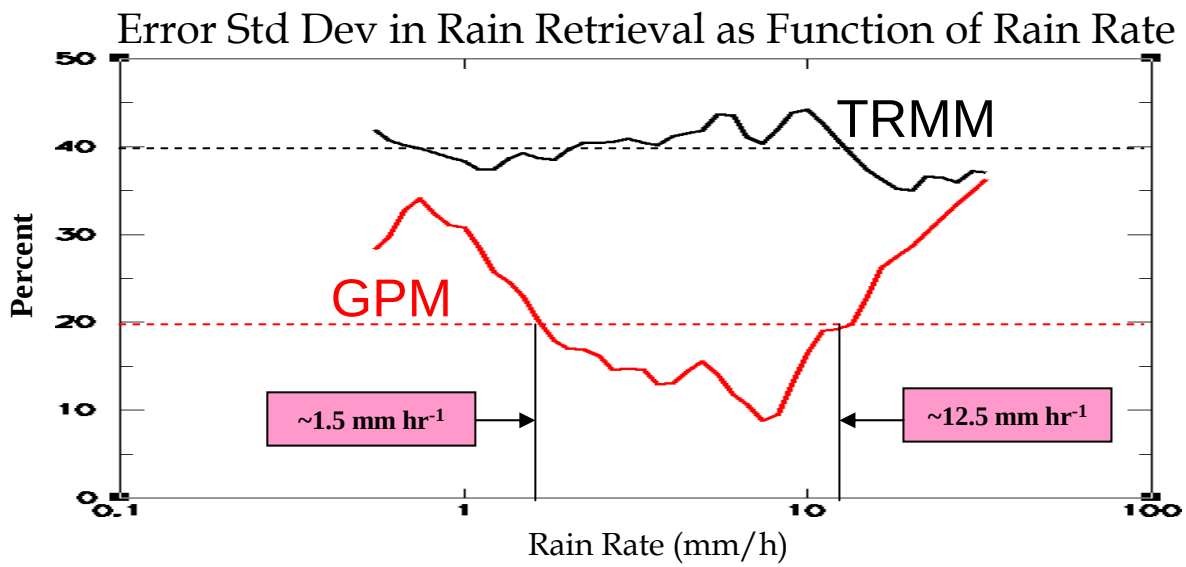
- *Ground truth and calibration*
- *Cooperative international partners*

## Precipitation Processing System

- *Global precipitation products from diverse sensors and sources*
- *Cooperative international partnerships*

## Ku-Ka Bands (13.6-35 GHz), JAXA, 4km horizontal, 250m vertical

- ***Increased sensitivity for light rain and snow detection*** – *Addition of Ka band (35.5 GHz) to Ku band (13.6 GHz) improves the detection threshold from 0.5 to 0.17 mm/h, significantly improving measurements of rain occurrences in light rain and snow events*
- ***Better overall measurement accuracy*** - *replacing the surface reference technique for path-integrated-attenuation correction with dual-frequency methods*
- ***More detailed microphysical information*** – *detection of drop size distribution and identification of liquid, frozen, and mixed phase precipitation, leading to an improved cloud database for rain & snow retrievals for both the Core and constellation radiometers*




Simulated retrievals based on synthetic noises added to Hurricane Bonnie observations and an assumed drop size distribution

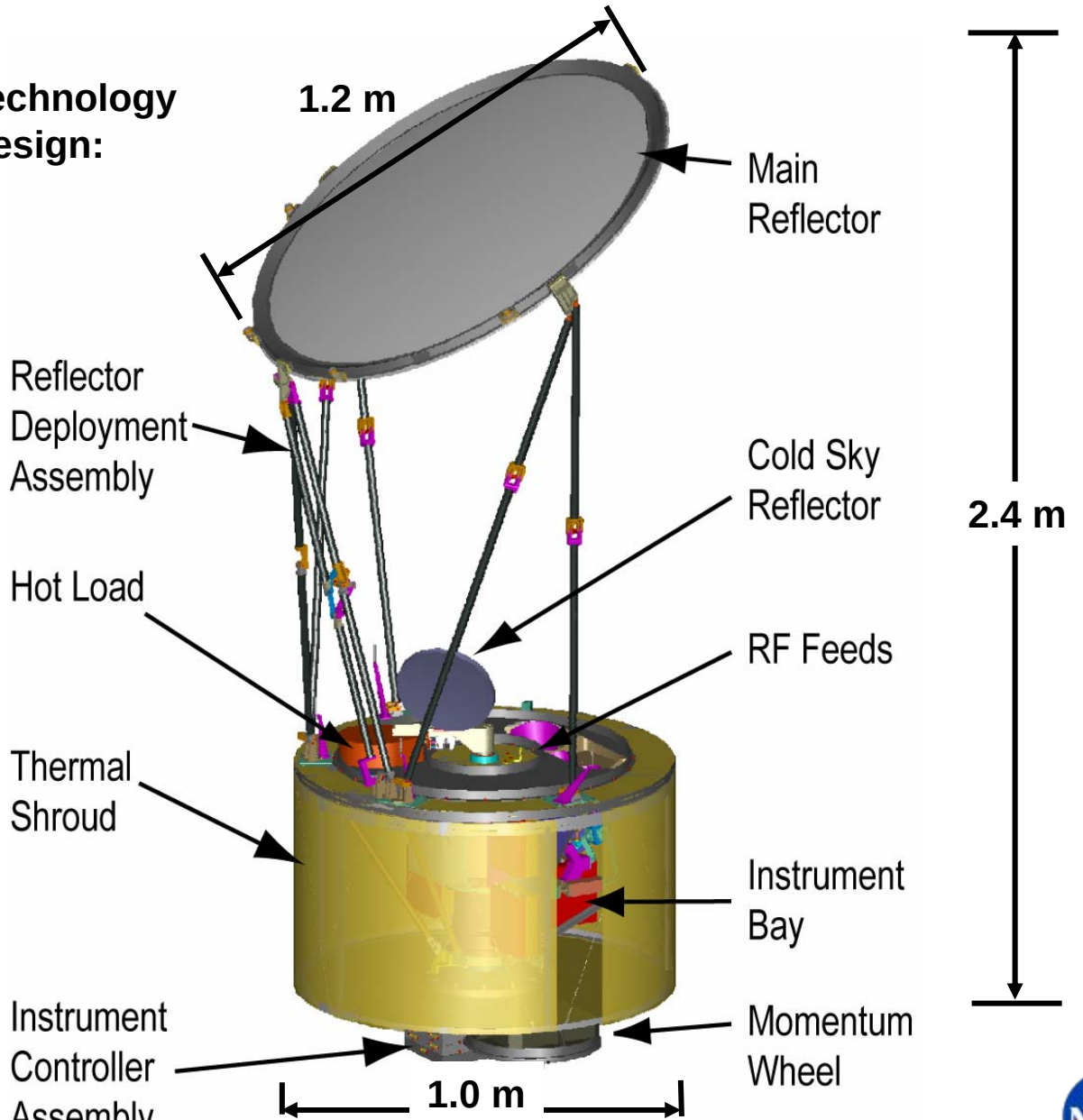
*Courtesy of Z. Haddad*

# GPM Microwave Imager (GMI)

**Ball Aerospace and Technology Corporation (BATC) design:**

**GMI Key Parameters**

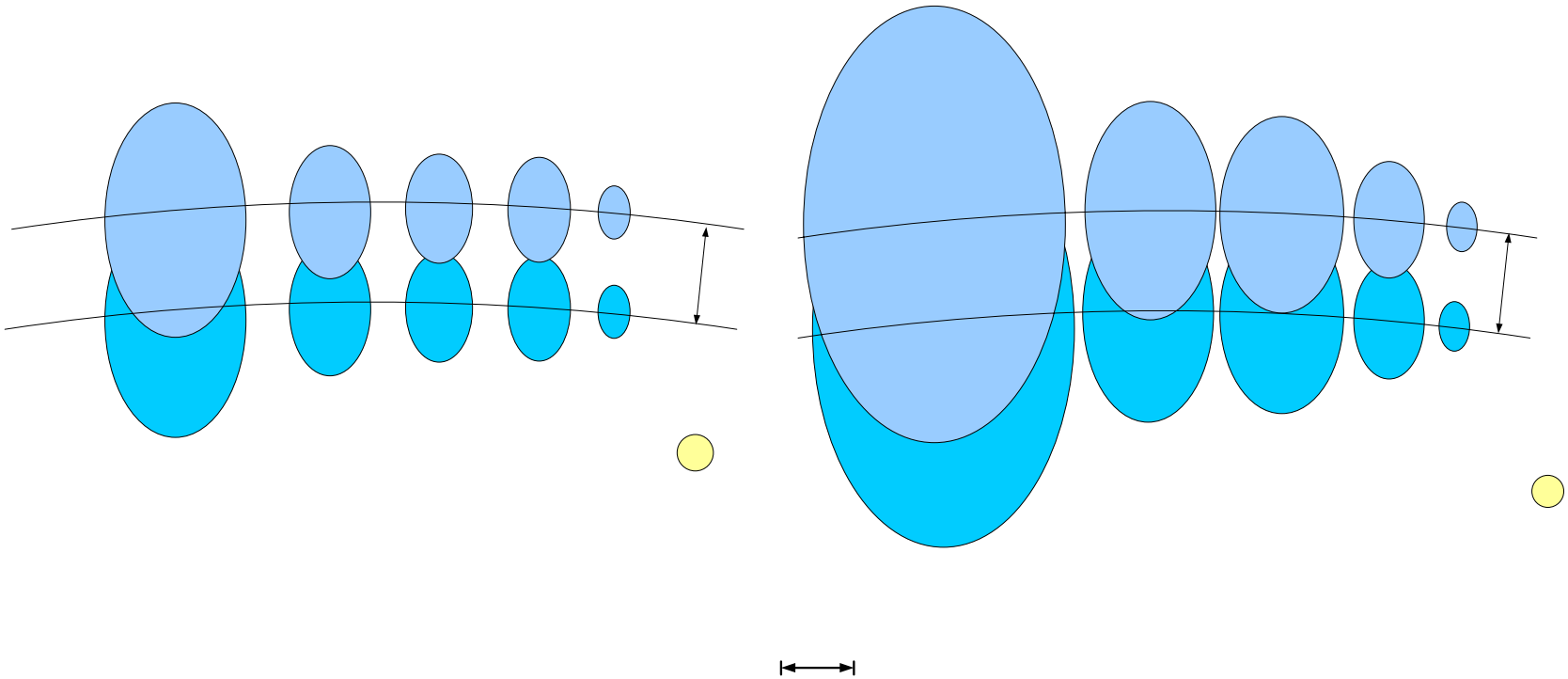
Mass:~100 kg
Power:~90 W
Data Rate:~25 kbps
Antenna Size:~1.2 m Diameter
Channel Set:
10.65 GHz, H & V Pol
18.7 GHz, H & V Pol
23.8 GHz, V Pol
36.5 GHz, H & V Pol
89.0 GHz, H & V Pol
(166 GHz, H & V Pol, and 183 GHz GHz, H & V Pol enhancement options)



# GMI Instantaneous Field-of-Views

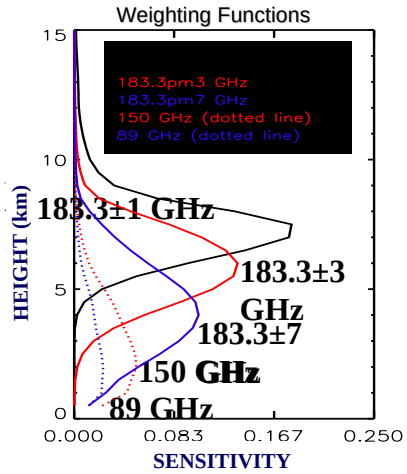
GPM / GMI at 407 km

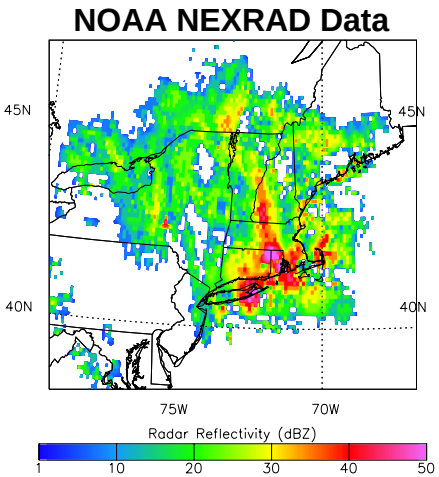
TRMM / TMI at 350 km



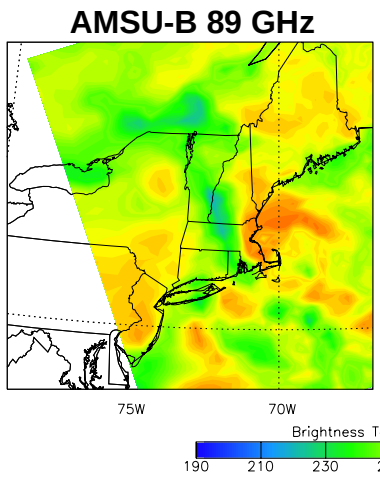
# Science value of HF channels on GMI

- *Measurement of frozen precipitation*
- *Measurement of light rain*
- *Improved PMW retrieval algorithms over land*
- *Improved precipitation measurements in mid- and high-latitudes in cold seasons*
- *HF channels on GPM Core enabling the testing and evaluation of constellation PMW algorithms using the DPR*

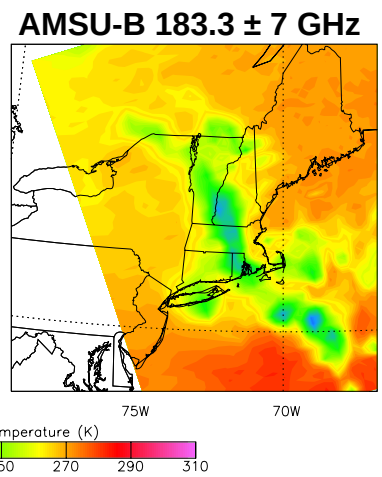


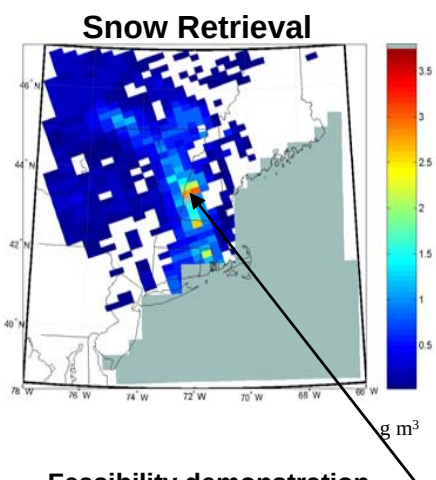

Radar reflectivity composite of the March 5-6, 2001 New England blizzard (75 cm of snow fell on Burlington, VT)




Surface effects evident over the Great Lakes, the St. Lawrence River, and along the Atlantic coast. Cannot distinguish surface from cloud effects.




Surface effects screened by water vapor. Snowfall appears over New England as low brightness temperatures

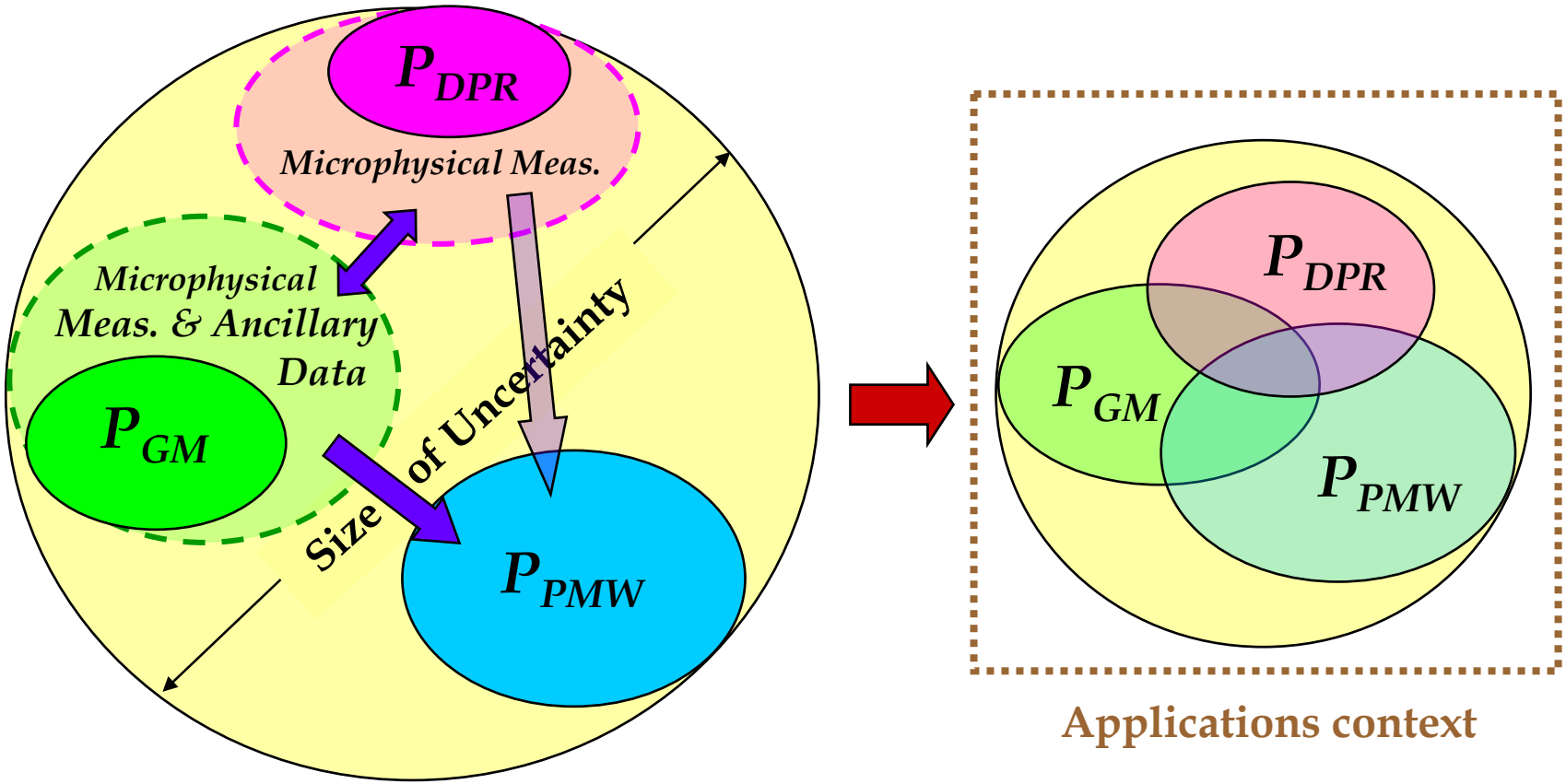



Feasibility demonstration of snowfall retrieval using HF channels

*G. Skofronick-Jackson et al. (GSFC)*

# GPM Validation Concept

*GPM validation goes beyond direct comparisons of surface precipitation rates between ground and satellite measurements*




**GV goal is to provide ground observations for direct satellite product assessment and for algorithm/application improvements**

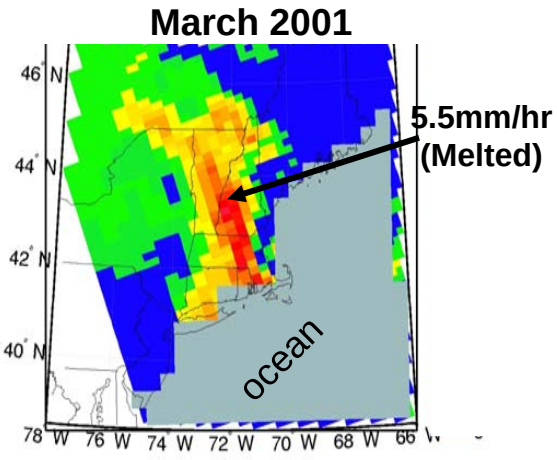
## US GPM Ground Measurement Advisory Panel (Chair: Chris Kummerow) recommends:

- ***Surface precipitation statistical validation sites for direct assessment of GPM satellite data products:***
  - *Co-located with existing or upgraded national network (NEXRAD etc.) and dense gauge networks*
- ***Precipitation process sites for improving understanding of precipitation physics, modeling, and satellite retrieval algorithms:***
  - *Continental tropical, mid- and high-latitude sites (including orographic/coastal sites and targeted sites for resolving discrepancies between satellite algorithms)*
  - *Oceanic tropical and mid-latitude sites*
  - *Aircraft measurements*
- ***Integrated hydrological sites for improving hydrological applications:***
  - *Co-located with existing watersheds maintained by other US agencies and international research programs*

**These sites can be designed to overlap.**

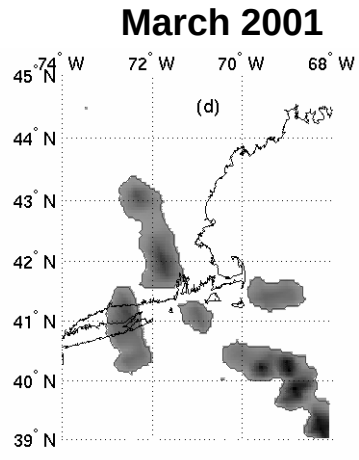
# Falling Snow Retrieval Algorithms

## Physically Based



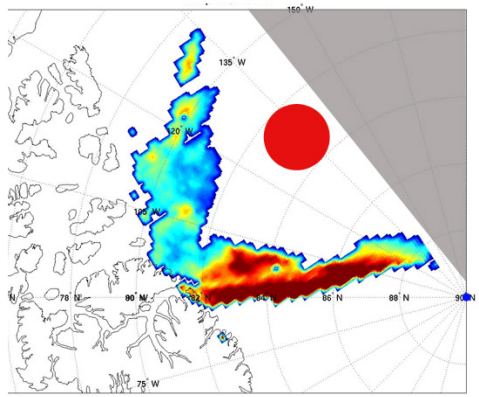

NASA Goddard/U. Wash.
Kim, 2004 Thesis

## Neural Networks



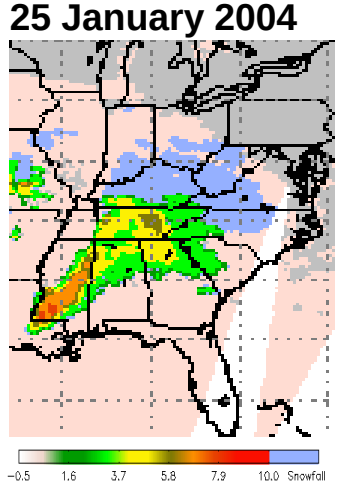

MIT
Chen and Staelin
Trans Geosci Remote Sens 2003

## Neural Nets/Polar



MIT, Staelin

## Snow Detection



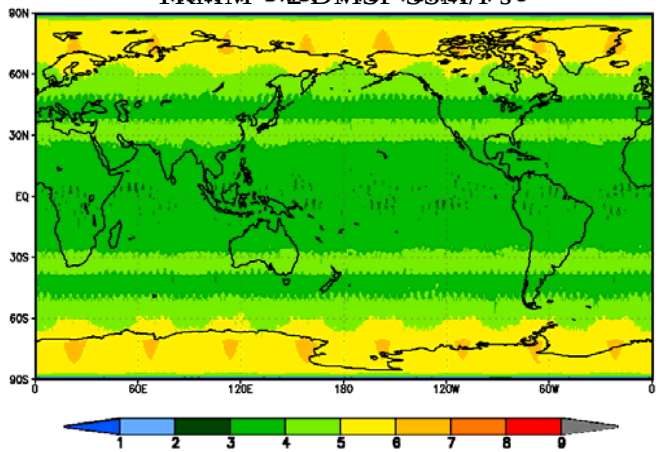

NOAA
Kongoli, et al
Geophys Res. Letters 2003
& Ferraro et al TGARS 2005

Algorithm development and improvement for GMI core and constellation systems

# Temporal Sampling Risk Mitigation using AMSU Satellites

## TRMM Reference

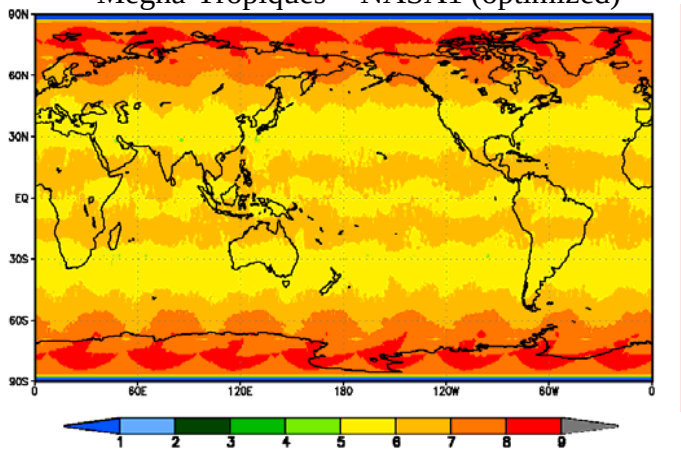
TRMM + 2 DMSP SSM/I's




Observations Per Day

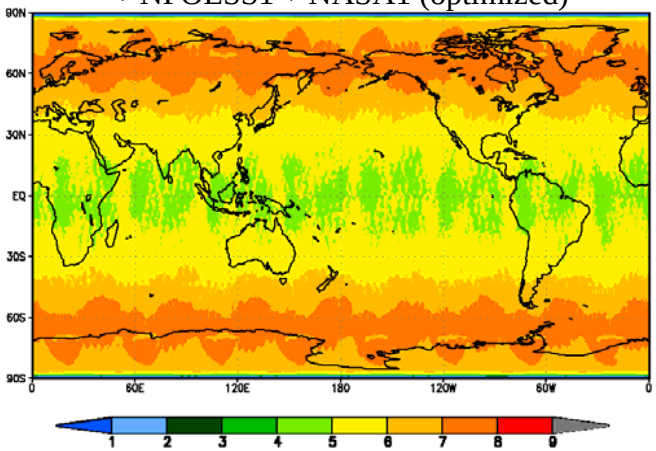
## Expected GPM Constellation

GPM Core + 3 NPOESS's + GCOM-W + EGPM + Megha-Tropiques + NASA1 (optimized)



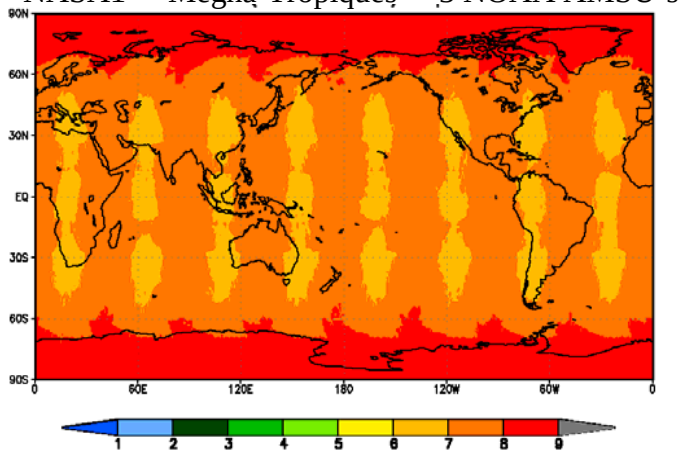

## GPM Base Configuration

GPM Core + DMSP F18 + DMSP F19 + NPP + NPOESS1 + NASA1 (optimized)




## GPM + 3 AMSU

GPM Core + 3 NPOESS's + GCOM-W + EGPM + NASA1 + Megha-Tropiques + 3 NOAA AMSU's



- ***Pathway from HF sounders to HF imagers***
  - *Quantitative assessment of different products over land and oceans.*
  - *Evaluation of sounder retrieval methodologies and error estimates*
  - *Development of improved retrieval algorithms, especially over land*
- ***Algorithm development***
  - *Assessment of precipitating snowfall and light rain retrieval methodologies*
  - *Development and enhancement of reliable algorithms appropriate to DPR, GMI, and DPR+GMI observations*
- ***Validation***
  - *Appraisal of GV and in situ requirements for snow and light rain*
  - *Statistical, process, and hydrological needs*

**The GPM Core satellite provides an unprecedented opportunity to measure falling snow and light rain to calibrate and improve PMW precipitation algorithms**